6.0 CONCEPTUAL SUMMARY

6.1 Introduction

This section presents a conceptual model that describes the evolution of current environmental conditions at and immediately adjacent to the site. The model is based on historical site information along with the qualitative and quantitative results of the various site assessments and investigations. The model was developed to provide an integrated summary of the key processes that have occurred (or are occurring) resulting in the existing conditions at the site and the affected off-site areas. In brief, the model addresses potential on-site source areas at each operable unit comprising the site along with the key fate and transport mechanisms that are responsible for the migration of MGP-related materials and chemicals from the source areas and its distribution in the environment.

As discussed in **Section 1.5**, the former MGP and affected off-site areas have been classified into four operable units, designated Operable Unit 1 (OU-1) through Operable Unit 4 (OU-4). This organization into operable units is necessary, as the potential source areas and associated fate and transport processes that have resulted in the distribution of MGP residuals in the environment were distinct for each operable unit. In keeping with this premise, individual conceptual models are presented below for each operable unit. In addition, historical background of the site is summarized below in order to provide an overview of the activities that were performed during operation of the former MGP. The regional hydrogeologic settings for each operable unit are similar, and accordingly, descriptions of the key local and regional hydrogeologic characteristics are provided in **Section 6.2** following the historical overview.

The former Bay Shore MGP site operated between 1889 and approximately 1973 and entailed the handling, storage and management of feedstocks for gas production as well as intermediate byproducts generated as a result of the gas production process. During the life of the plant, gas was manufactured from various solid and liquid fuel feedstocks such as coke, coal and oil. In 1918, the plant began operating using the carbureted water gas (CWG) process. The plant was later converted to operate using the oil-gas process. Manufacturing operations were

conducted on the Bay Shore property, while the Brightwaters Yard property was used to support gas manufacturing and distribution. After gas production ceased sometime in the early 1970s, the gas plant structures remained on site until demolition of the plant in 1973.

From at least 1925 to the early 1970s, the Brightwaters Yard Site (OU-3) served as a storage facility for feedstock materials and commercial byproducts used and generated at the Bay Shore MGP. From approximately 1963 to 1977, a 1-million gallon aboveground storage tank was located in the southwest corner of the Brightwaters Yard site. The tank was used to store a light petroleum distillate, similar to kerosene and referred to as H-fuel. In addition, piping associated with the tank as well as drip oil tanks were located in this portion of the site.

The gas produced at the Bay Shore site was transferred from the Generator House, run through scrubbers and separators to concentrate the gas, remove and collect economically important intermediate chemicals that were produced, such as naphthalene, and to remove unwanted impurities such as sulfur and cyanide. Leaks and/or spills from piping, storage and/or treatment structures during the transfer and distribution processes of feedstocks and MGP residuals resulted in these materials impacting subsurface soil and groundwater in the vicinity of the former structures and downgradient from the site.

A portion of the wastewater generated at the former MGP was treated at an on-site wastewater treatment facility. Subsequent to treatment, treated wastewater was transported via underground piping to a cesspool located east of the site. The so-called former Cesspool was located in the vicinity of the former headwater pond for Watchogue Creek/Crum's Brook (OU-4).

6.2 Hydrogeologic Setting

Geology in the vicinity of the site consists of four primary stratigraphic units, which are the fill unit, a recent (post-glacial) silt/clay unit, glacial outwash deposits and the Magothy formation.

The fill material encountered throughout the site is highly variable in character and thickness and consists of brown to black sands and gravels with varying amounts of glass, brick, coal, ash, clinker and wood. The fill material extends throughout the southern two-thirds of the Bay Shore Site with the thickest component located along the southernmost portion of the parcel. The fill material within the southern portion of the site contains extensive amounts of construction/demolition (C&D) material, such as brick, metal piping, concrete block and wood. Based on the nature of the C&D material, it is likely that it originated as a result of the demolition of the MGP facility which occurred in 1973. Furthermore, test pits completed within the Bay Shore site indicated the presence of foundations and other subsurface structures remaining on this portion of the former MGP site. The locations of these structures appear to be consistent with available historic drawings.

The recent (post-glacial) silt/clay unit was detected at the Bay Shore Site and Bay Shore West Parcel as discontinuous lenses at or near the water table. Due to its discontinuous nature, this strata does not appear to be an effective confining unit in this portion of the former MGP site. However, the recent silt/clay unit appears to be fairly continuous in the Brightwaters Yard within the vicinity of the former H-fuel tank described above. As a result, this strata does behave as a partial confining unit in this portion of the former MGP site.

Consistent with regional geology, a continuous sequence of glacial outwash sand and gravel exists throughout the site and surrounding areas. The glacial outwash deposits comprise the entire Upper Glacial aquifer. Within the site, the upper surface of the outwash deposits is located immediately below the surficial topsoil layer in areas where the fill and recent silt/clay units are absent. The medium to coarse sands encountered throughout the site, as well as areas to the south, are typical of glacial outwash deposits which comprise the Upper Glacial aquifer within southern Suffolk County. These relatively coarse sediments contain low total organic carbon (TOC) and exhibit excellent water transmitting properties, with horizontal hydraulic conductivities ranging from 147 feet per day to 270 feet per day. The average TOC in sediments at the site is approximately 1 percent. The fraction of organic carbon is the dominant characteristic of an aquifer affecting the capacity to adsorb organic chemicals, such as BTEX and low molecular weight PAHs. The combined effects of high groundwater flow rates and low TOC

allow organic chemicals to migrate through the Upper Glacial aquifer with little attenuation due to adsorption by organic carbon.

The glacial outwash deposits rest on top of the low permeable Magothy formation which consists of a fine sand, silt and clay varying from light gray to black in color and ranging from hard to slightly plastic in texture. The Magothy formation beneath the site has an average vertical permeability of only 1.74×10^{-5} cm/second or 0.05 feet/day. Therefore, the upper portion of the Magothy formation acts as an effective confining unit limiting the vertical migration of any chemical constituents beyond the glacial outwash deposits.

Based on the hydraulic gradient as determined using measured water table elevations and hydraulic conductivity described above, groundwater flows at a rate of approximately 2.3 ft/day. Consequently, there is little lateral dispersion of the dissolved BTEX and PAHs in the off-site Bay Shore plume (OU-2).

6.3 Fate and Transport of Nonaqueous Phase Liquids

Low viscosity tar and oil that may have been discharged by the former MGP site would have behaved as nonaqueous phase liquids (NAPL) migrating vertically through the soil column under the force of gravity until contacting the water table approximately 6 to 8 feet below grade. Due to the transmissive nature of the glacial outwash sands and gravels underlying the site, migration of NAPL would have been relatively rapid. As it migrated downward through the soil, a portion of the NAPL would have become trapped in pore spaces in response to capillary forces creating a zone of immobile residual NAPL within the vadose zone. If the NAPL was able to penetrate the water table, the NAPL would also migrate horizontally in a downgradient direction under the influence of groundwater flow.

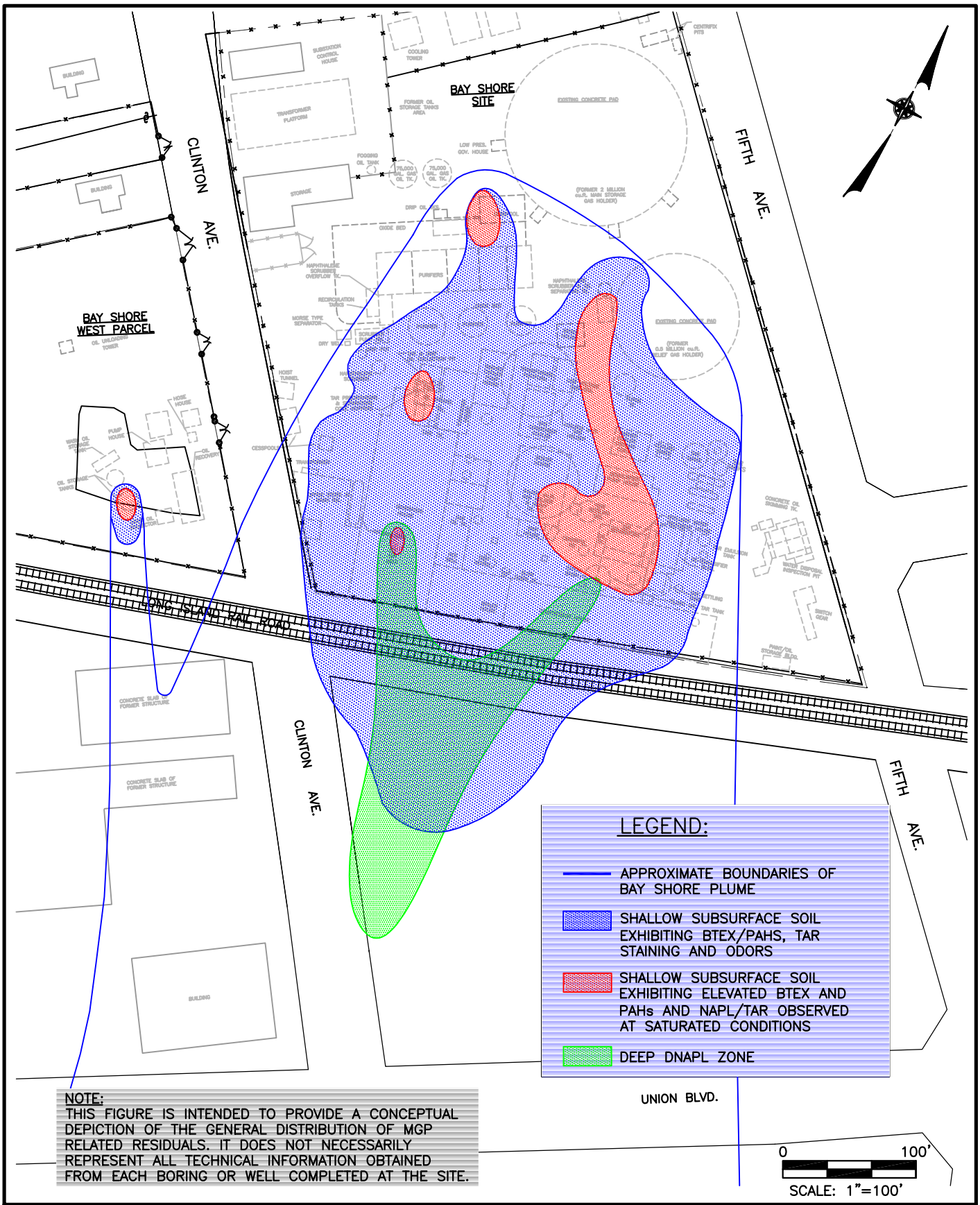
Any NAPL which is less dense than water, commonly referred to as light nonaqueous phase liquids or LNAPL, would have spread laterally on the shallow water table after it migrates vertically and infuses groundwater. The NAPL would become further immobilized in soil pores as the water table naturally fluctuates in the vertical direction in response to changes in

groundwater recharge rates. This would have created a vertical zone of residual LNAPL, typically referred to as a "smear zone." Tars or oils which are more dense than water, referred to as dense nonaqueous phase liquid or DNAPL, would continue to migrate through the soil column until either the volume required to sustain gravity-driven migration was inadequate due to solubilization or loss of mass as the result of the DNAPL being trapped in pore spaces, or an impermeable unit was encountered.

6.4 Bay Shore Site, Bay Shore West Parcel and Bay Shore Plume (Operable Units 1 and 2)

Areas of subsurface soil exhibiting evidence of NAPL, were encountered primarily in close proximity to former MGP structures located at the Bay Shore Site. Where observed, saturated NAPL/tar in subsurface soil in the central third of the site is generally limited to approximately 20 to 30 feet below ground surface (bgs). The occurrence of saturated NAPL/tar in soil at depths greater than 30 feet bgs is generally limited to the southern third of the site and immediately adjacent downgradient areas. **Figure 6-1** provides the approximate locations of each on-site area containing NAPL/tar at saturated levels along with the estimated extent of soil exhibiting tar staining and odors.

The observed distribution of NAPL/tar in subsurface soil indicates a southerly migration of this material from on-site source areas primarily located in the southernmost third of the site to downgradient areas. NAPL/tar migration appears to be predominantly horizontal in nature at and below the water table. However, in the vicinity of the southern property boundary, a downward vertical migration component appears to be present. As a result, there appears to be a deeper NAPL/tar zone or DNAPL zone located above the Glacial/Magothy formation interface. As illustrated by **Figure 6-1**, this deeper DNAPL zone appears to originate from former MGP structures located in the southern third of the site and extends approximately 250 feet south of the site. LNAPL was not observed within shallow monitoring wells or test pits completed within the Bay Shore site. In addition, LNAPL was not observed in shallow monitoring wells located immediately downgradient of the site.



BAY SHORE/BRIGHTWATERS FORMER MGP SITE FINAL REMEDIAL INVESTIGATION
BAY SHORE, NEW YORK

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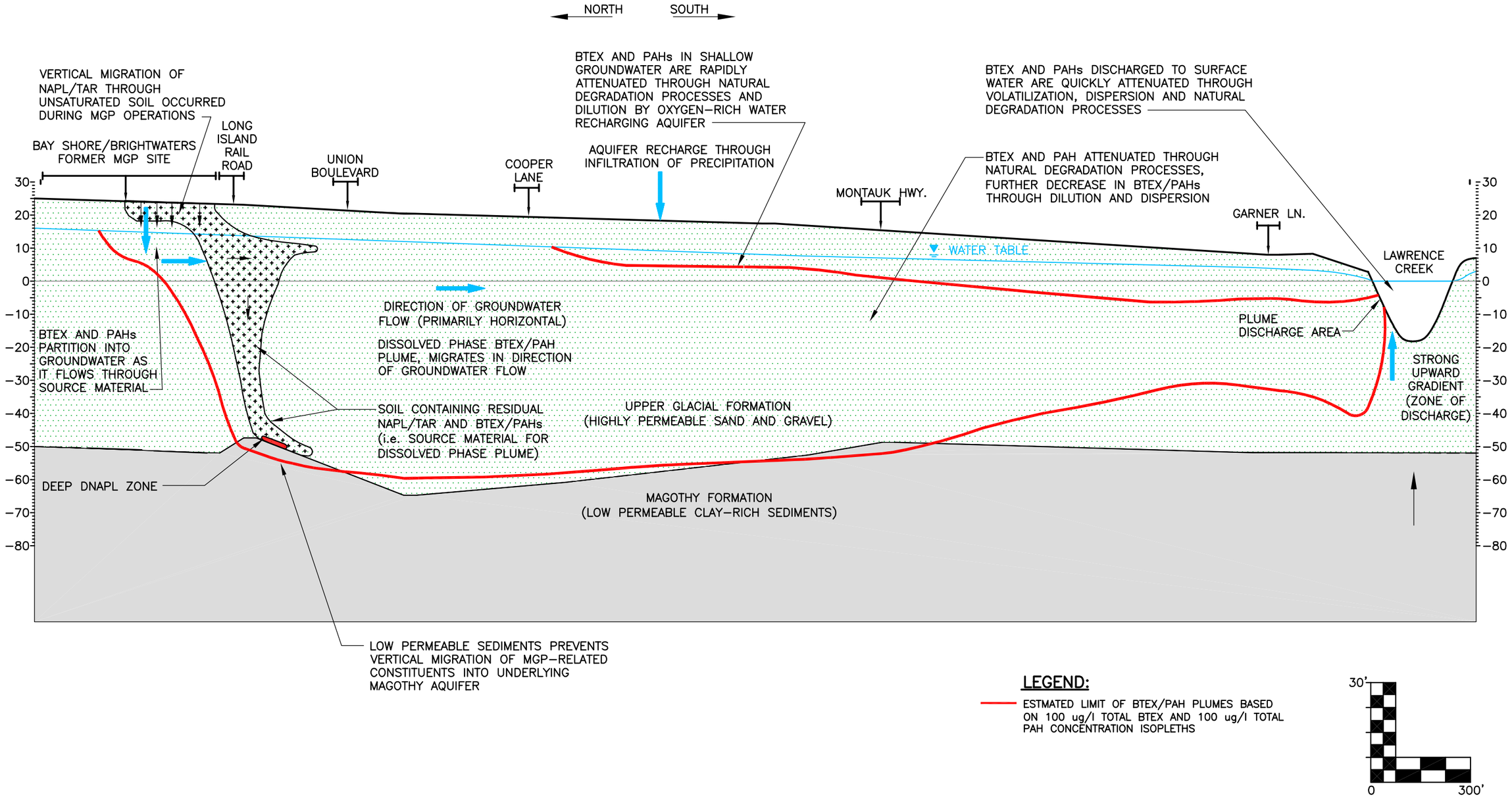
CONCEPTUAL MODEL OF BTEX AND PAH SOURCE AREAS LOCATED AT THE BAY SHORE SITE, BAY SHORE WEST PARCEL AND ADJACENT OFF-SITE AREAS

FIGURE 6-1

As shown on **Figure 6-1**, the Bay Shore West Parcel contains a relatively small area of subsurface soil containing elevated BTEX located in the vicinity of the two former Oil Storage Tanks. Based on analytical data and field observations, which are discussed under **Section 4.2.2**, this area of elevated BTEX is found to be relatively shallow in depth with the highest concentrations being present at or near the water table which is characteristic of an LNAPL smear zone. Analysis of an oil sample collected from an abandoned pipe recovered from the Bay Shore West Parcel indicated this material was less dense than water further supporting the concept that the BTEX present in subsurface soil at the Bay Shore West Parcel was likely attributed to a spill or leak of an LNAPL during the operation of the former MGP.

A schematic cross section that transects the site in a north-south direction and extends downgradient along the approximate centerline of the Bay Shore plume south to Lawrence Creek is provided on **Figure 6-2**. Consistent with the areal distribution of soil containing MGP residuals shown on **Figure 6-1**, **Figure 6-2** indicates that the majority of residual NAPL and soil containing BTEX and PAHs is limited to the source areas and areas where NAPL has migrated along and in the vicinity of the water table. **Figure 6-2** also shows that NAPL and affected soils in the deep portions of the glacial outwash deposits are limited to the adjacent off-site area immediately south of the site. The vertical migration of NAPL beyond the glacial outwash sediments is limited by the underlying low-permeability silt and clay that comprises the Upper Magothy formation.

Once the NAPL enters the subsurface soil, the more soluble components of the mixture are susceptible to dissolution through direct infiltration of precipitation, as well as groundwater flowing through the soil that contains the residual NAPL. As discussed above and in **Section 3.0**, groundwater in the Upper Glacial aquifer flows at the relatively high rate of 2.3 feet/day and the glacial outwash deposits are relatively poor in organic carbon content. Due to these conditions, the relatively soluble compounds, such as BTEX and low molecular weight PAHs, which leach from the NAPL and become dissolved in groundwater will tend to stay in solution and migrate at rates that are similar to the natural flow rate of groundwater. In contrast, the high molecular weight PAHs which have lower aqueous solubilities and higher potentials to adsorb to organic carbon in the aquifer matrix have a tendency to remain within the immobile NAPL present in the



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FATE AND TRANSPORT CONCEPTUAL MODEL OF BTEX AND PAHs IN SUBSURFACE ENVIRONMENT THROUGH BAY SHORE PLUME CENTERLINE

FIGURE 6-2

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soil, become sorbed onto soil and/or migrate a limited distance from this source. This is supported by the groundwater data which indicates on-site groundwater collected from areas which contained NAPL exhibit elevated levels of BTEX and both low and high molecular weight PAHs. Immediately downgradient of the site, the same high molecular weight PAHs were only sporadically detected in groundwater and at lower concentrations.

During migration in the Bay Shore plume, the dissolved BTEX and to a lesser degree, PAHs, have been degraded through both aerobic and anaerobic biodegradation processes. Evidence of these processes include elevated carbon dioxide, depleted dissolved oxygen concentrations and elevated concentrations of anaerobic byproducts such as reduced iron, reduced manganese and ammonia. **Figure 6-2** also illustrates that the plume is located several feet below the water table downgradient of Cooper Lane. The lack of BTEX and PAHs present in this portion of the plume is likely attributed to the relatively rapid attenuation of BTEX/PAHs through the introduction of oxygen-rich water recharging the aquifer at the water table throughout the length of the plume.

As shown on **Figure 6-2**, the Bay Shore plume is migrating in the direction of the natural flow of groundwater (south to southeast), extending from the Bay Shore Site to as far west as the southeast corner of the Bay Shore West Parcel: a width of approximately 500 feet. The total length of the plume is estimated to be approximately 3,400 feet with the plume discharging to Lawrence Creek, a tidally influenced surface water body located south of Montauk Highway. Groundwater flow in the downgradient portion of the plume transitions from a predominantly horizontal to a more vertical flow regime south of Montauk Highway. The vertical component of flow increases until groundwater discharges into the tidal portion of Lawrence Creek. While the plume discharges to a relatively narrow zone of Lawrence Creek, surface water sampling conducted within this discharge zone found relatively low concentrations of BTEX and PAHs within surface water. The lack of BTEX and PAHs in surface water within the discharge zone is likely attributable to the following fate and transport factors:

- Groundwater containing BTEX and PAHs is rapidly diluted as the result of mixing with surface water and other water sources which also discharge to the creek.

- BTEX dissolved in surface water will have the propensity to volatilize from the water and undergo biological decay. Studies have shown that BTEX compounds readily degrade through natural processes within surface water.

6.5 Brightwaters Yard Site Groundwater Plume (Operable Unit 3)

As discussed in **Section 6.2**, the Brightwaters Yard site is underlain by fill, the recent (post-glacial) silt/clay unit and the transmissive glacial outwash sediments. Investigations conducted to date have identified a BTEX/PAH source area within the southwestern portion of the site which is associated with the former storage of H-fuel discussed under **Section 6.1**. This BTEX/PAH source area is estimated to be approximately 30,000 square feet in area and is approximately 14 feet thick. The density of H-fuel was likely less than that of water and, accordingly, would have spread laterally along the water table surface as a LNAPL as described under **Section 6.3**. As the result of the natural vertical fluctuation of the water table, the LNAPL would tend to distribute within soil pores over a "smear zone" bounded by the historic high and historic low water table elevations. Due to the position of the recent silt-clay unit and the degree of the water table fluctuation, NAPL will have a propensity to become trapped in more permeable sands and peat deposits interbedded within this unit creating isolated zones of bulk NAPL within the smear zone. However, the majority of the NAPL will likely remain in a residual and immobilized state within the pores of the soil as the result of capillary forces. These factors significantly limit the ability to physically remove the trapped LNAPL. Despite these conditions, KeySpan has had some success in recovering NAPL from the source area. This recovery effort was followed up by treating the source area with an in-situ chemical oxidation remedial technology.

Over time the more soluble components, that include BTEX and low molecular weight PAHs such as naphthalene, have leached from the H-fuel source area and into the shallow groundwater. As a result, the Brightwaters Yard plume consists of dissolve-phase BTEX and PAH compounds originating from a source area located in the southwest corner of the site and has migrated to the south along with the natural flow of groundwater. The plume has been determined to be approximately 200 feet wide and 1,400 feet long.

As the dissolved BTEX and PAHs migrate downgradient, they are being attenuated through biodegradation, as indicated by increases in carbon dioxide and depletion of dissolved oxygen in the Brightwaters Yard plume. Beginning in September of 2000, KeySpan began actively treating the plume with an oxygen injection technology. The oxygen amendments were implemented to accelerate naturally occurring aerobic biodegradation of BTEX and low molecular weight PAHs in the plume. The effectiveness of the natural biodegradation (i.e., prior to the oxygen injection) and the oxygen-enhanced biodegradation is clearly demonstrated by the continued decreases in concentrations of BTEX and PAHs in the Brightwaters Yard plume. The decreased concentrations of these comparatively soluble components also demonstrate the ongoing mass removal of dissolved chemicals.

The groundwater in the Brightwaters Yard plume ultimately discharges to the north end of O-Co-Nee Pond. However, analysis of surface water and sediment samples collected from the pond indicate little if any impact associated with the Brightwaters Yard plume. The lack of BTEX and PAHs in the surface water of O-Co-Nee Pond is likely attributable to the same fate and transport factors attenuating these compounds in Lawrence Creek as described under **Section 6.4**.

6.6 Watchogue Creek/Crum's Brook (Operable Unit 4)

A former industrial Cesspool located at the headwaters of Watchogue Creek was the historical discharge point for treated wastewater generated at the former Bay Shore MGP site. Wastewater discharged to the creek flowed south to a small pond area, which was subsequently backfilled. Currently, the creek headwaters start immediately south of the LIRR property, located approximately 500 feet east of the former MGP site. The creek flows south under Union Boulevard, eventually discharging to the Great South Bay. Investigations conducted to date indicate soil, groundwater and surface water sediments exhibit detectable levels of BTEX and PAHs. In general, BTEX and PAH concentrations decrease rapidly with increasing depth. However, at several soil borings completed in the vicinity of the former Cesspool, the detectable concentrations of PAHs persisted at depths well below the water table. In these soil borings, field observations of recovered soil included staining, sporadic blebs of NAPL and/or hydrocarbon

and naphthalene odors. Additionally, groundwater samples collected in the vicinity of the borings that exhibited these conditions also contained detectable concentrations of BTEX and/or PAHs.

Water discharged to the former Cesspool from the former Bay Shore MGP historically may have contained NAPL and dissolved BTEX and PAHs. The dissolved chemicals would likely have readily leached into and become diluted to reduced concentrations by groundwater and migrated away. Any MGP-related NAPL that was discharged to the former Cesspool remained in the immediate vicinity and acted as a secondary source for dissolved BTEX and PAHs.

As indicated by subsurface soil data, BTEX compounds were only detected at low concentrations in subsurface soil below a depth of 10 feet, whereas PAHs were detected to a depth of up to 30 feet below grade. This is consistent with the vertical migration of NAPL that may have been discharged to the former Cesspool from the former MGP. The absence of BTEX in the subsurface soil deeper than 10 feet bgs indicates that the NAPL may have had a different chemical make-up from the NAPL typically encountered at the former MGP site or was extensively weathered. The NAPL impacted sediments within, beneath and immediately surrounding the former Cesspool are currently acting as a local source of groundwater impacts. The concentrations of BTEX and PAHs decrease rapidly downgradient from the former Cesspool. During the period of its operation, water from the former Cesspool migrated downgradient to the former Watchogue Creek headwaters pond area where it locally impacted sediments in the pond producing what is now a minor low-concentration secondary source area for BTEX and PAHs to groundwater.

6.7 Remedial Action Plan

KeySpan and the NYSDEC are developing a Remedial Action Plan (RAP) to address the environmental implications associated with the Bay Shore/Brightwaters former MGP site. That Plan will include a number of remedial measures, both within the site boundaries and in the community, to eliminate, reduce or contain sources of the MGP-related contaminants that are

found in the defined groundwater plumes in the community and to eliminate or limit the pathways through which residents, workers and other members of the public could be exposed to the contaminants associated with the former MGP operations. The Plan will include several remedial measures, designed to protect public health and the environment.